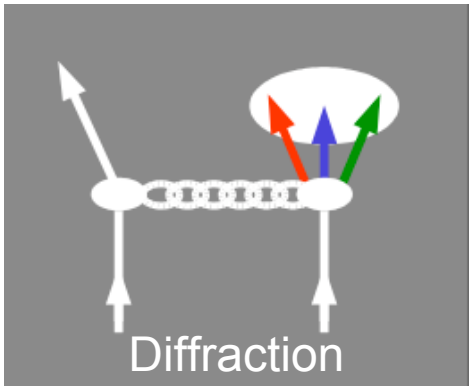
Diffraction at the Tevatron

XXXIII International Conference on High Energy Physics
Moscow :: 28 July 2006

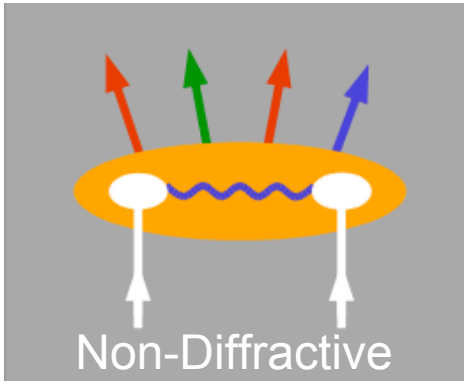
Andrew Hamilton
Université de Genève
for the CDF and DØ Collaborations

Introduction

Diffraction: An exchange with the quantum numbers of the vacuum.



Vacuum QN Exchange



Color Exchange

Goals of Diffractive Program at the Tevatron:

- Understand the nature of diffractive exchange
- Test the feasibility of diffraction as a tool to search for new physics at the LHC

Outline

Diffraction at DØ:

- physics plans

Inclusive Diffraction at CDF:

- ratio of SD/ND dijets
- Q^2 dependence of t in SD dijets

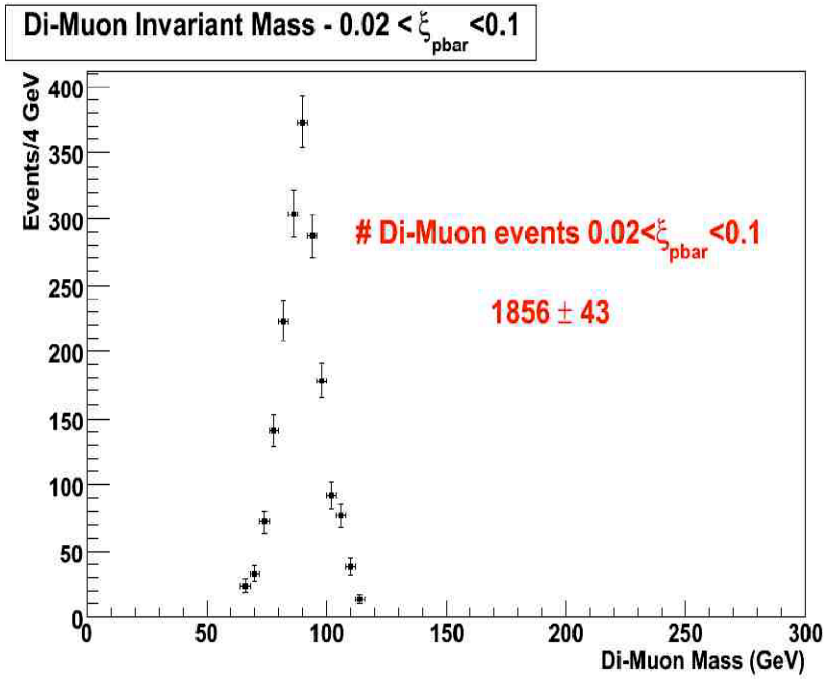
Exclusive Production at CDF:

- two mechanisms *(QED and QCD)*
- searches for QED mediated e^+e^-
- searches for QCD mediated $\gamma\gamma$ and dijets

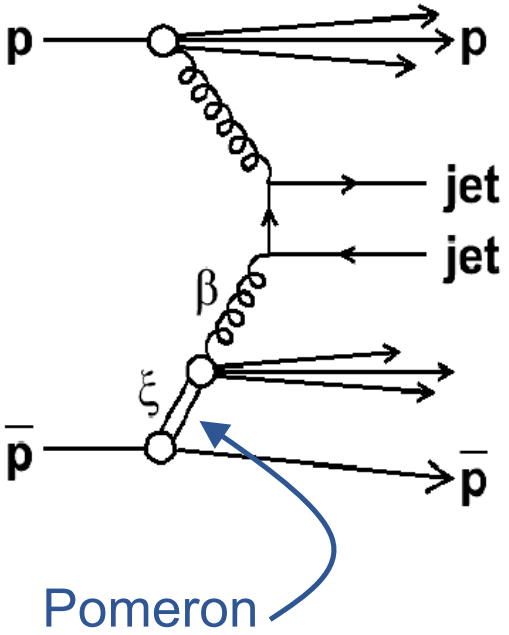
Summary

Diffractive Analyses in Progress at DØ:

- Double Pomeron Exchange (DPE) + Jets
- Diffractive Structure Function
- Diffractive Heavy Flavor
- Exclusive Production
- Diffractive *Z*
- Diffractive *W*
- Inclusive DPE



Inclusive Diffraction at CDF



Use high p_T jets as a probe to measure ***Diffractive Structure Function, F_{jj}^D***

Experimental Determination of F_{jj}^D

$$R(x_{Bj}) \text{ of } \frac{\sigma_{jj}(SD)}{\sigma_{jj}(ND)} = \frac{F_{jj}^D(x_{Bj}, Q^2)}{F_{jj}(x_{Bj}, Q^2)} \text{ (LO QCD)}$$

Data

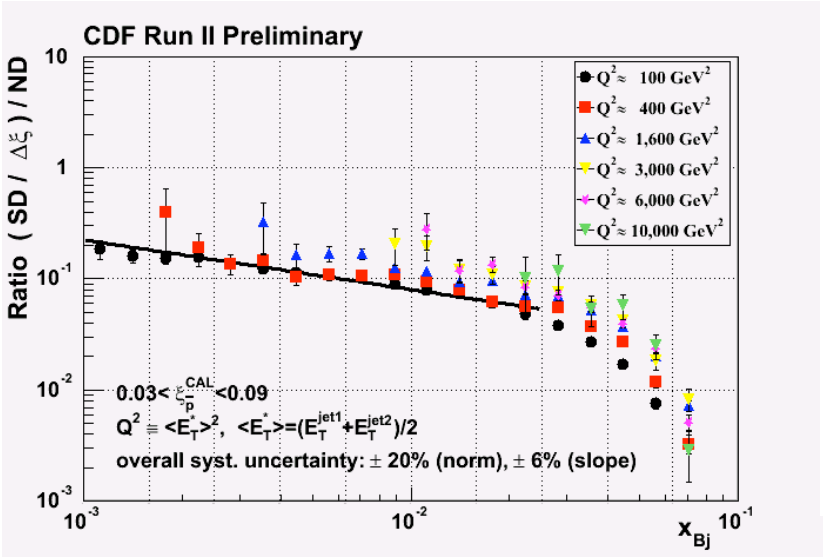
Known Proton PDF

$\beta = P_{parton} / P_{Pomeron}$

$\xi = P_{pomeron} / P_{proton}$

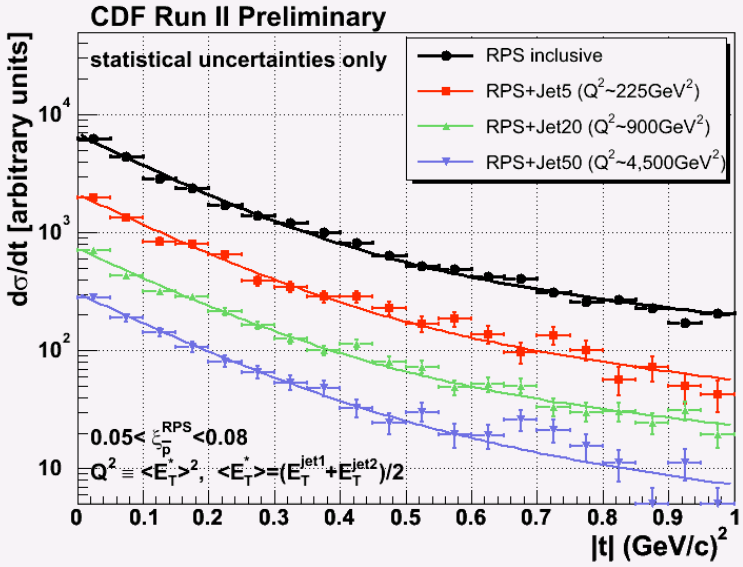
$t = (P_i - P_f)^2$

Inclusive Diffraction Results



- No Q^2 dependence
  ($100 < Q^2 < 10000$ GeV^2)
- The Pomeron evolves like the proton

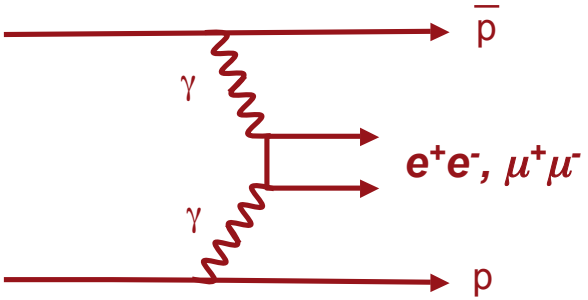
- Slope of $d\sigma/dt$ is independent of Q^2 in SD dijets



Exclusive Production at CDF

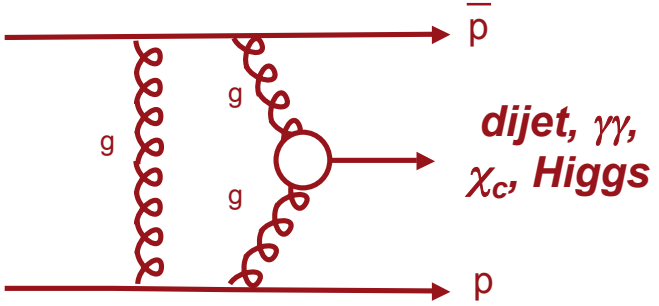
Exclusive Production: QED or QCD mediated

QED



- measure exclusive QED e^+e^- and $\mu^+\mu^-$ production at Tevatron to test feasibility of Luminosity measurement at LHC

QCD

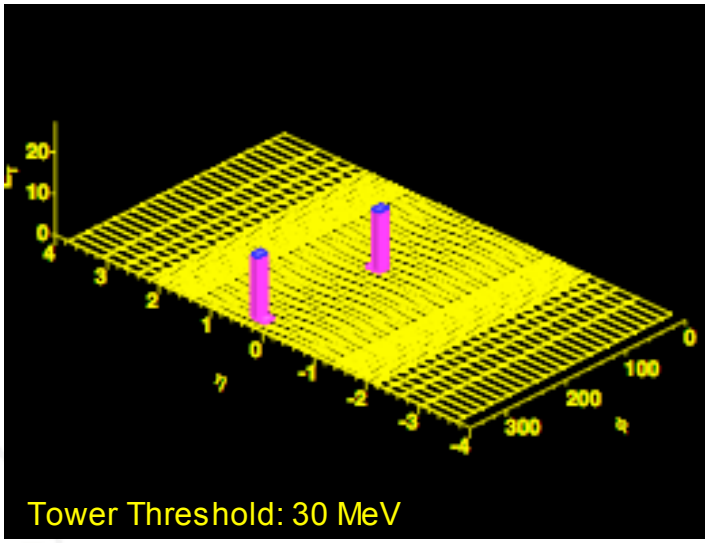


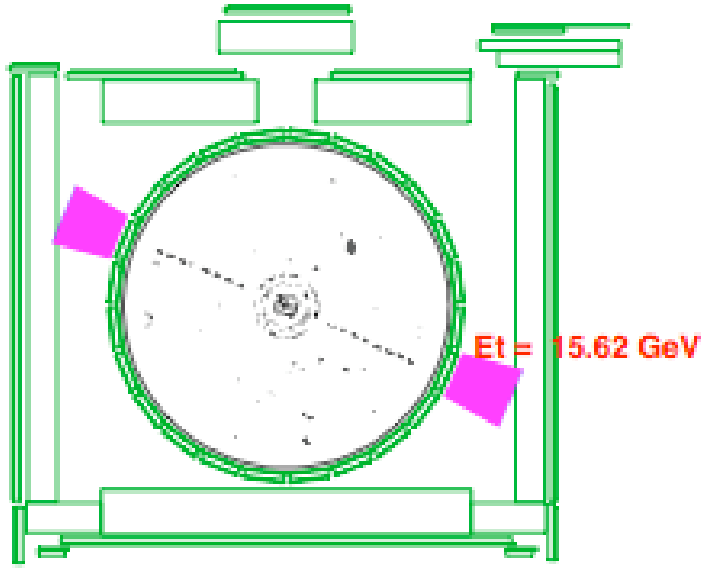
- measure exclusive QCD dijet and $\gamma\gamma$ production at Tevatron to constrain predictions on exclusive Higgs at LHC

QED Mediated e^+e^- Production

Exclusive e^+e^- events are selected by:

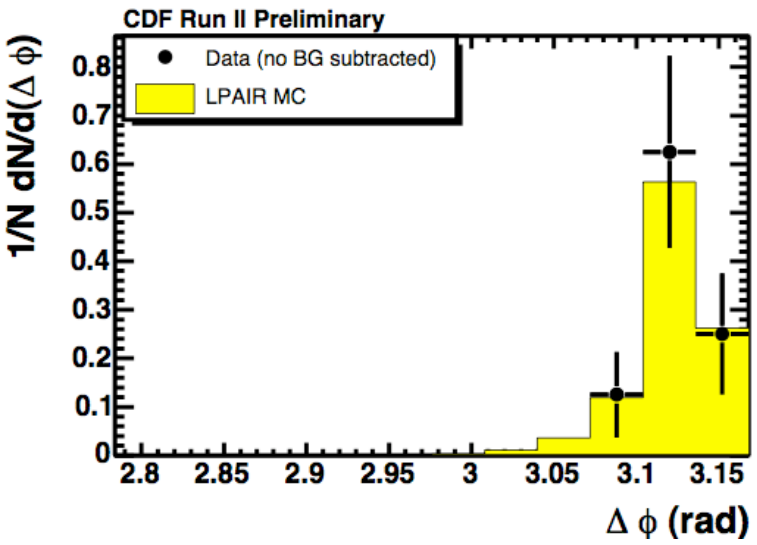
- reconstructing the e^+e^-
- requiring that there is no other activity in $|\eta|<7.4$
- *protons are not tagged*

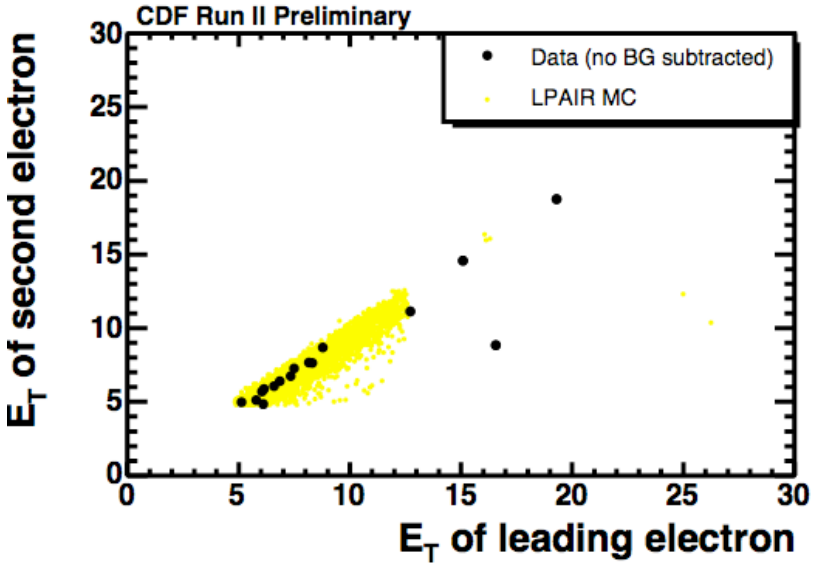




16 events similar are found.

QED Mediated e^+e^- Production

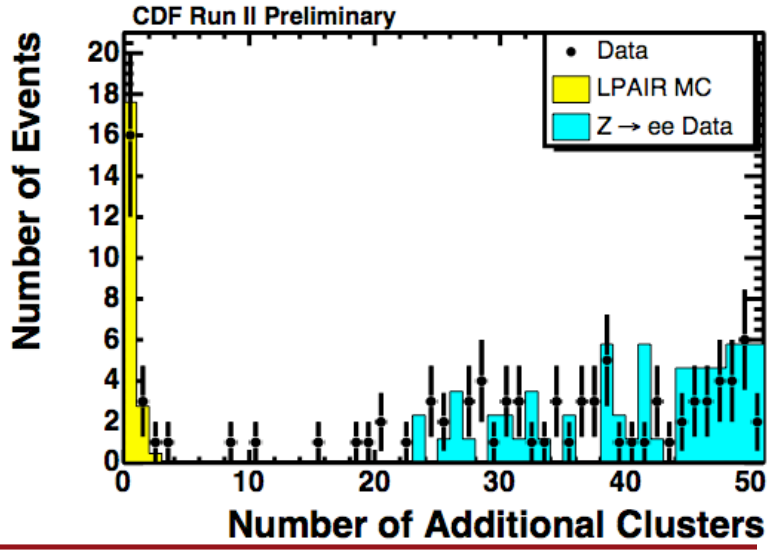




Background estimate: $2.1^{+0.7}_{-0.3}$

$\sigma_{exp} = 1.6\ ^{+0.5}_{-0.3}\ (stat)\ ^{+}_{-}0.3\ (sys)\ pb$

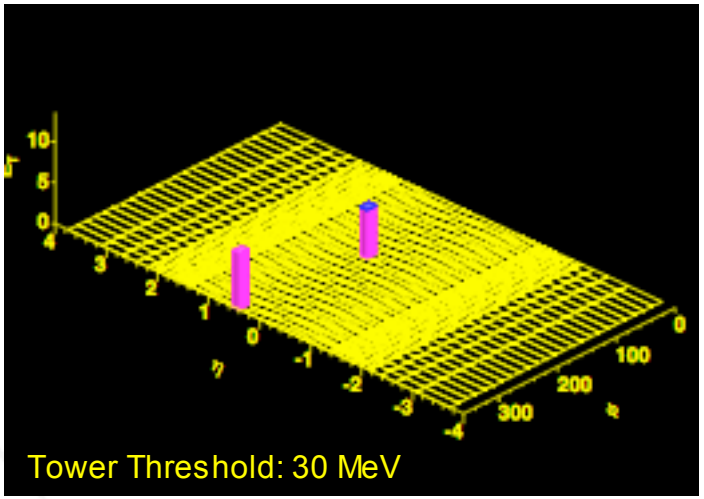
$\sigma_{LPAIR} = 1.711 \pm 0.008\ pb$

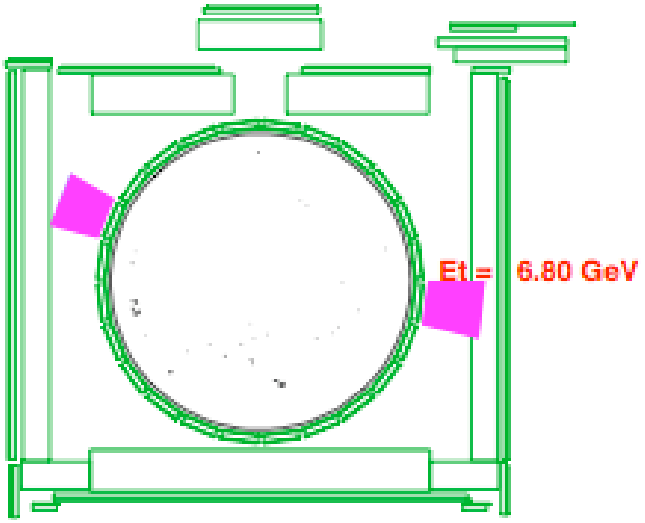


QCD Mediated $\gamma\gamma$ Production

Exclusive $\gamma\gamma$ events:

- selected in the same way as e^+e^- (except tracking)
- agreement of exclusive e^+e^- cross section gives confidence in analysis methodology





3 events are found.

1^{+3}_{-1} events are predicted from ExHuME MC

Monk & Pilkington. hep-ph/0502077

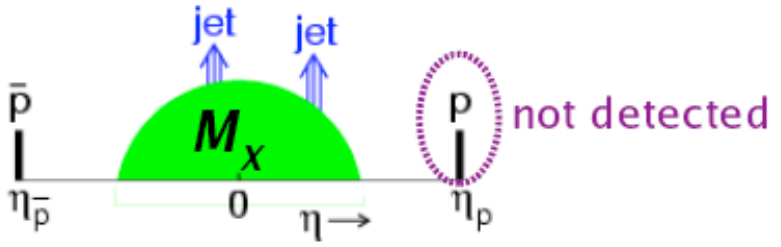
Background estimate is not yet complete

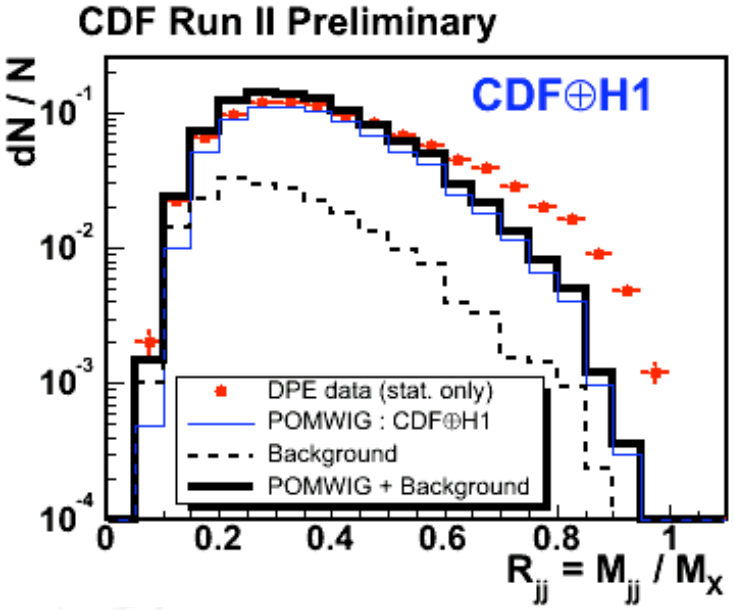
QCD Mediated Dijet Production

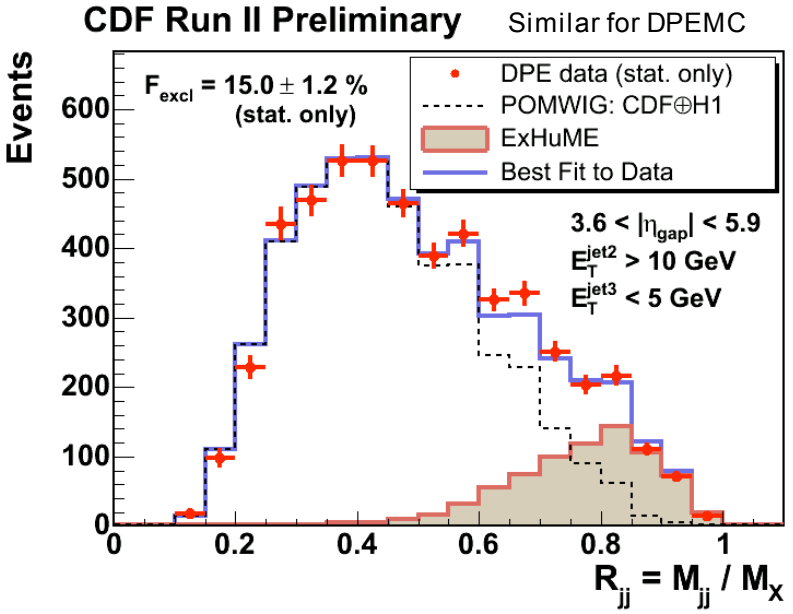
Strategy: • select DPE dijets: $\bar{p} + p \rightarrow \bar{p} + X\ (\geq 2jets + \ldots) + gap$

• examine the *dijet mass fraction* R_{jj}

$$R_{jj} = \frac{M_{jj}}{M_X}$$





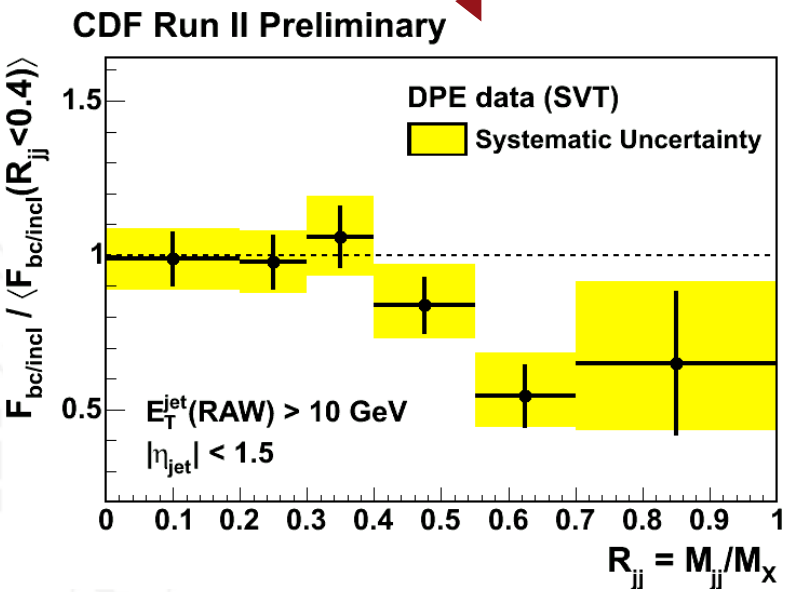


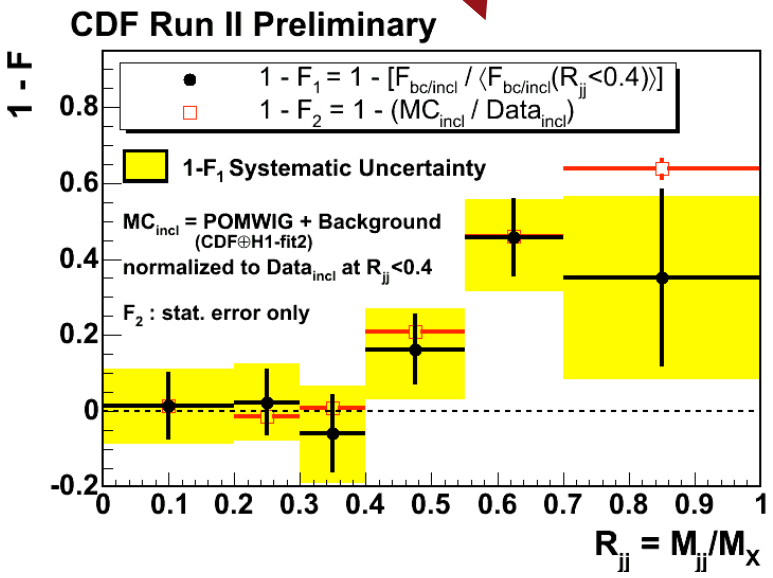
Another Observable:

- exclusive gg → qq is suppressed by J_Z=*0* rule
- exploit this by looking at ***fraction of heavy flavor (b/c) jets*** in dijet data as a function of R_{jj}

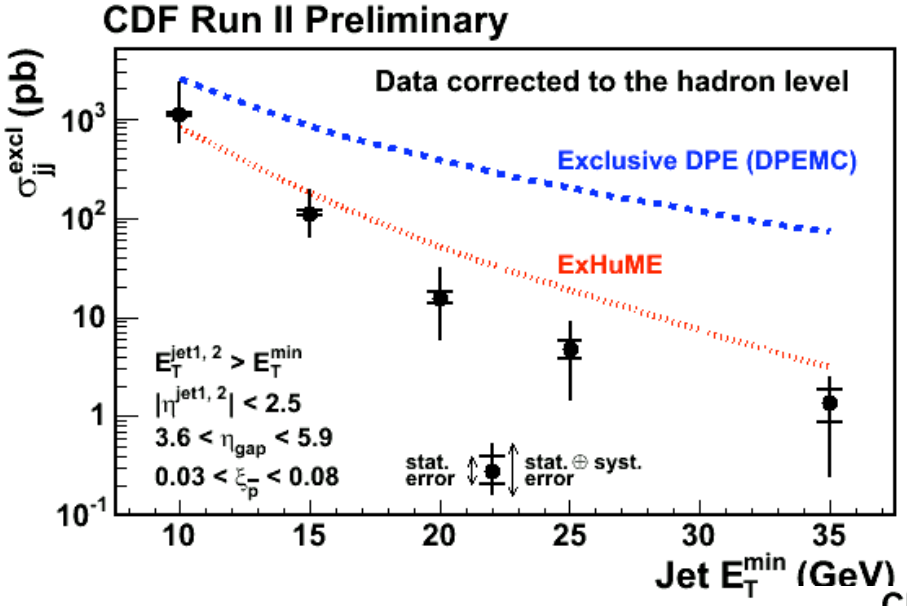
b/c jets suppressed at high R_{jj}

the two observables agree





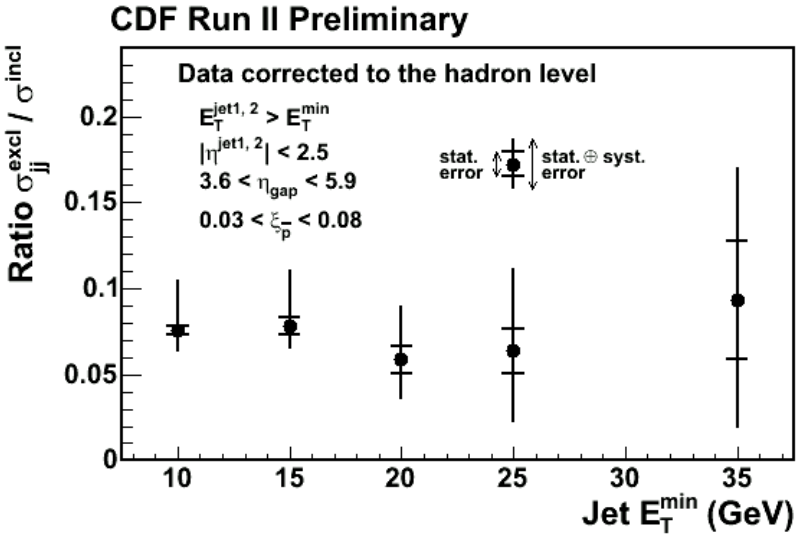
QCD Mediated Dijet Production



How does the cross section compare?

The data favors ExHuME MC

Ratio of exclusive to inclusive DPE cross sections is flat.



Summary

Diffraction at DØ:

- many analyses in progress

Inclusive Diffraction at CDF:

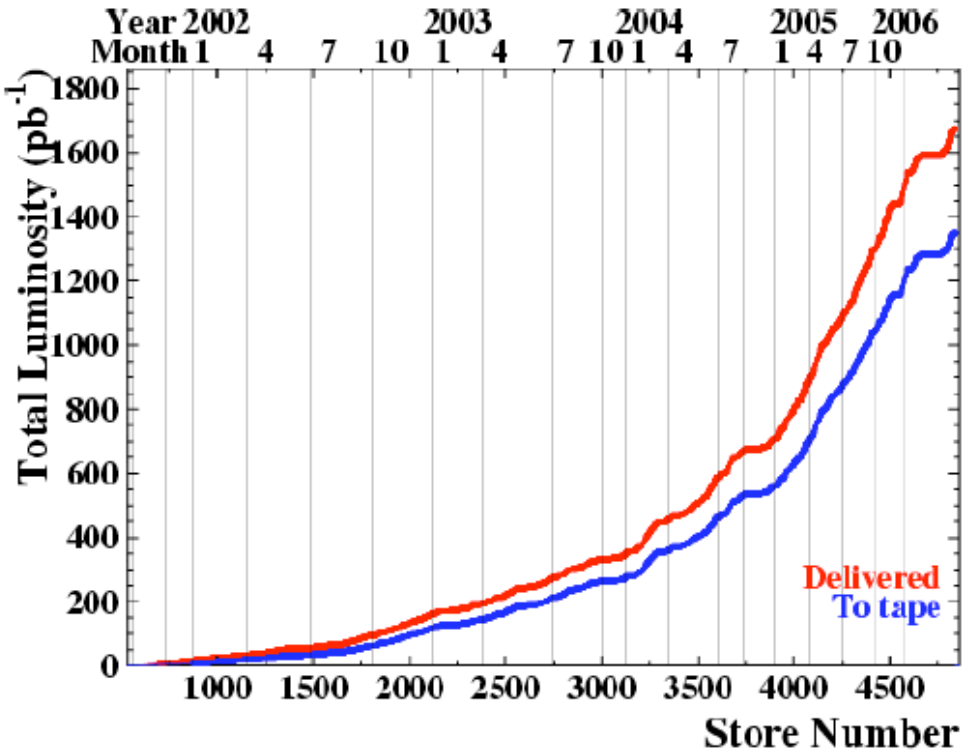
- Q^2 dependence of Diffractive Structure Function
- slope of SD dijet $d\sigma/dt$ is independent of Q^2

Exclusive Production at CDF:

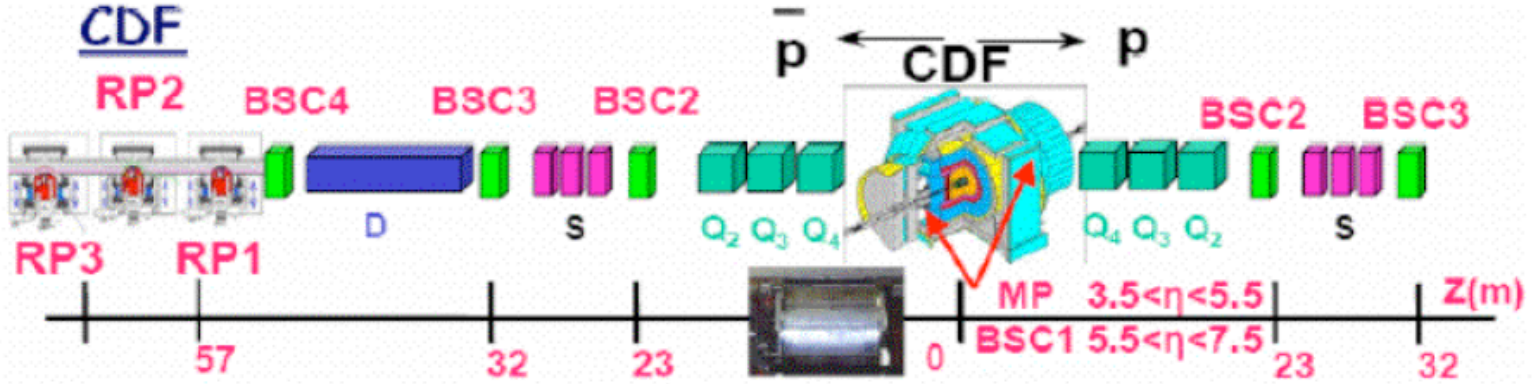
- observed e+e- production via QED exchange
- possible evidence for $\gamma\gamma$ production via QCD exchange
- observed dijet production via QCD exchange
- KMR / ExHuME predictions are consistent with data
- see previous talk for impact KMR of predictions on the LHC

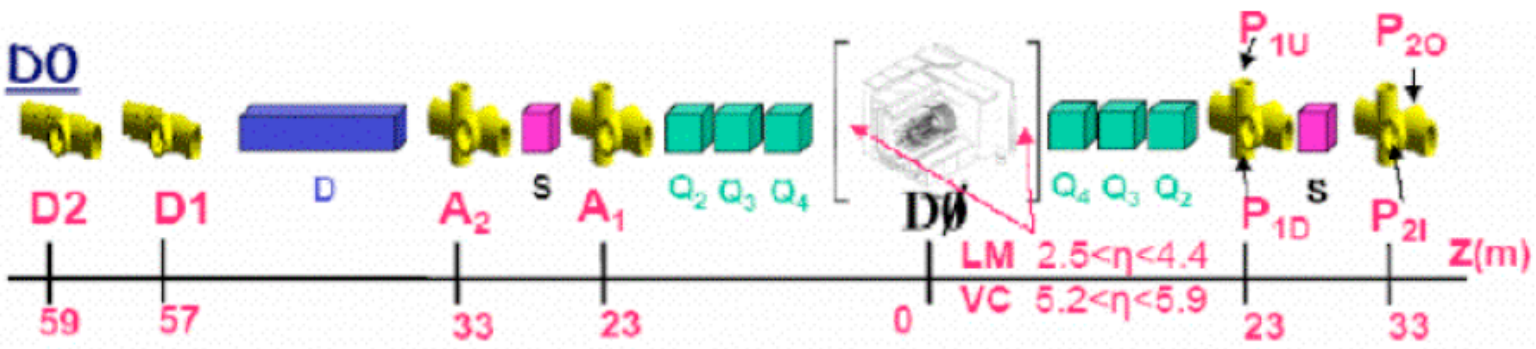
Backup Slides

Tevatron Luminosity



Forward Detectors





ee Numbers

$$\sigma = \frac{N_{candidates} - N_{background}}{\varepsilon_{cosmic}\,\varepsilon_{fsr}\,\varepsilon_{ee}\,\mathcal{L}_{eff}}$$

$N_{candidates} = 16^{+5.1}_{-3.2}$ (stat)

$N_{background} = 2.1^{+0.7}_{-0.3}$ (sys)

$\mathcal{L}_{eff} = 46 \pm 3$ (sys) pb^{-1}

$\varepsilon_{fsr} = 0.79 \pm 0.05$ (sys)

$\varepsilon_{cosmic} = 0.93 \pm 0.03$ (sys)

$\varepsilon_{ee} = 0.26 \pm 0.03$ (sys)

$$\sigma_{MEASURED} = 1.6^{+0.5}_{-0.3}\ (stat) \pm 0.3\ (sys)\ pb$$

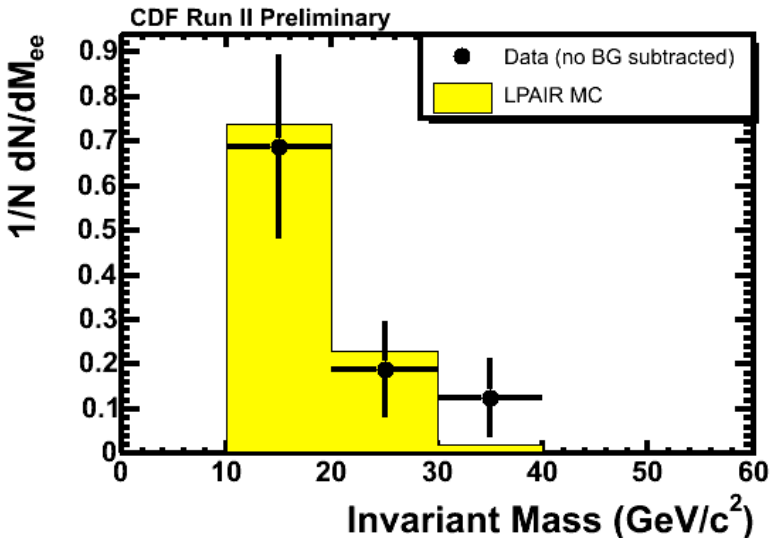
Poisson probability of 2.8 →16 = 5.0×10^{-8}
Corresponds to 5.4σ "observation"

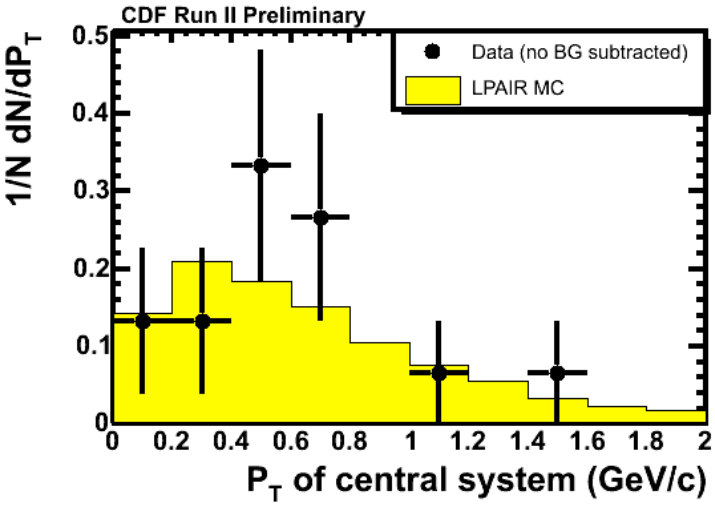
Agrees with LPAIR theory: $\sigma_{LPAIR} = 1.711 \pm 0.008$ pb

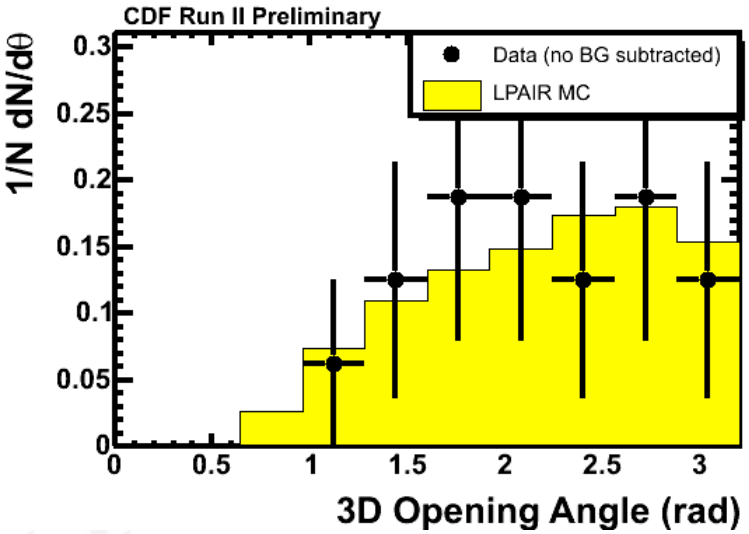
ee Numbers

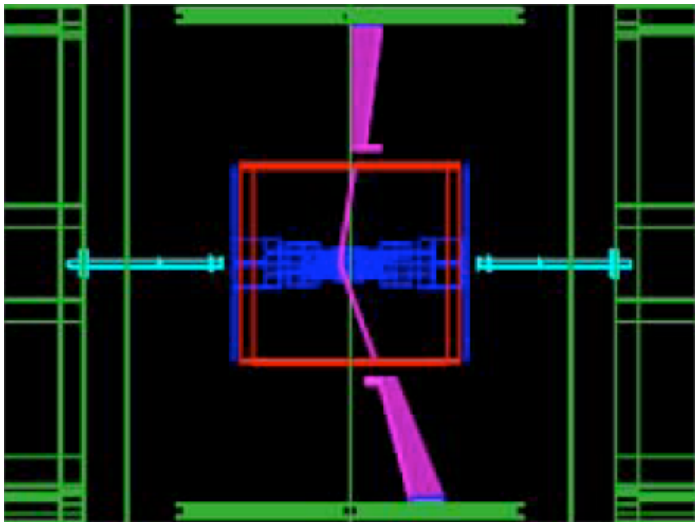
Fakes:	$0.0\ ^{+0.1}_{-0.0}$ events
Cosmic:	negligible
Exclusive:	$0.0\ ^{+0.3}_{-0.0}$ events
Dissociation:	2.1 ± 0.3 events
Total:	$\boldsymbol{2.1\ ^{+0.7}_{-0.3}}$ ***events***

ee Plots









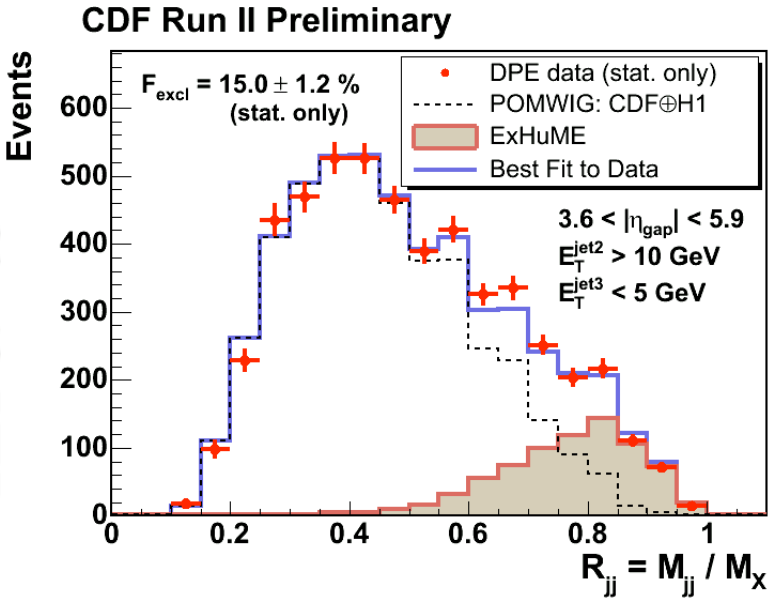
Dijet Plots

DATASETS:

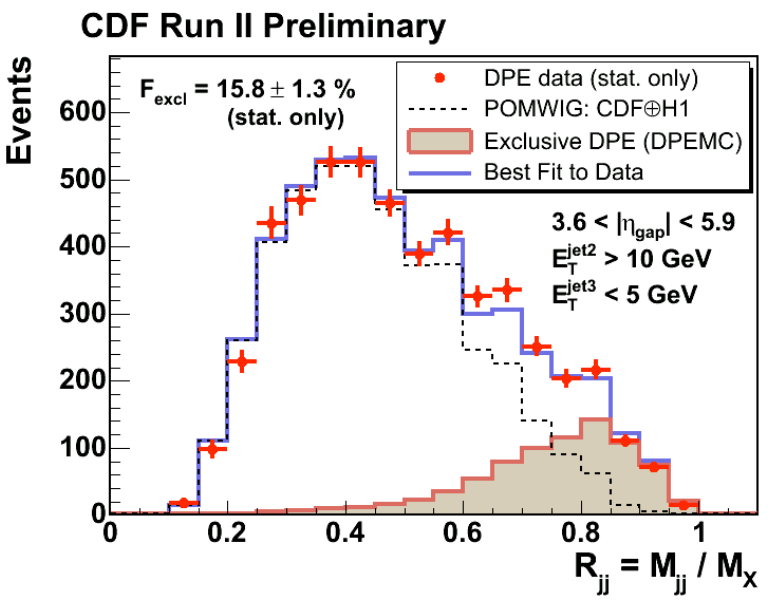
Exclusive / Inclusive fraction: 310 pb^{-1}

Heavy Flavor fraction: 200 pb^{-1}

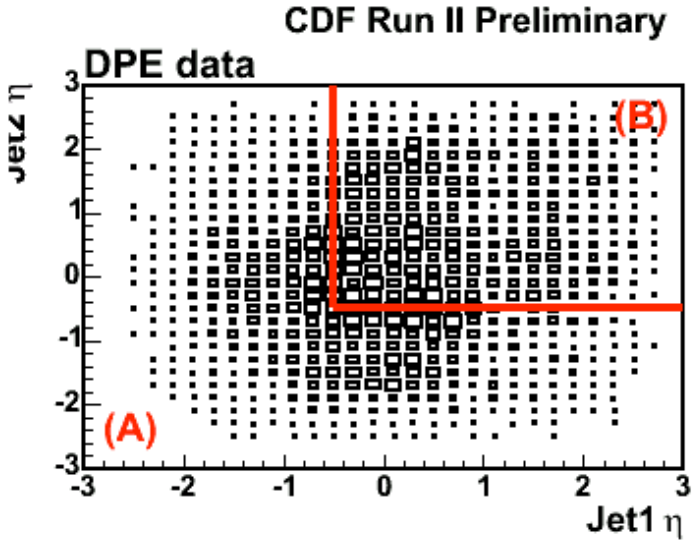
ExHuME

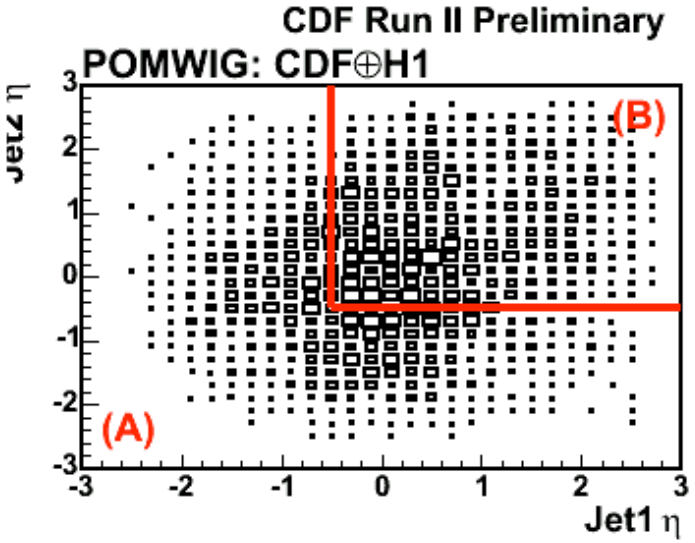


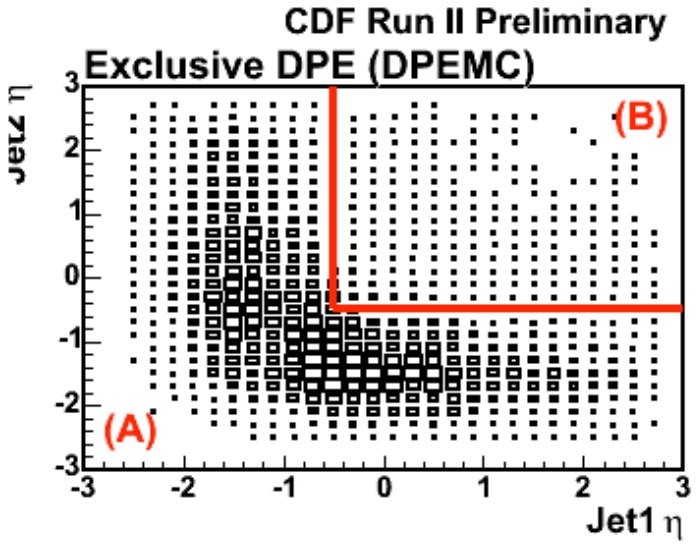
DPEMC

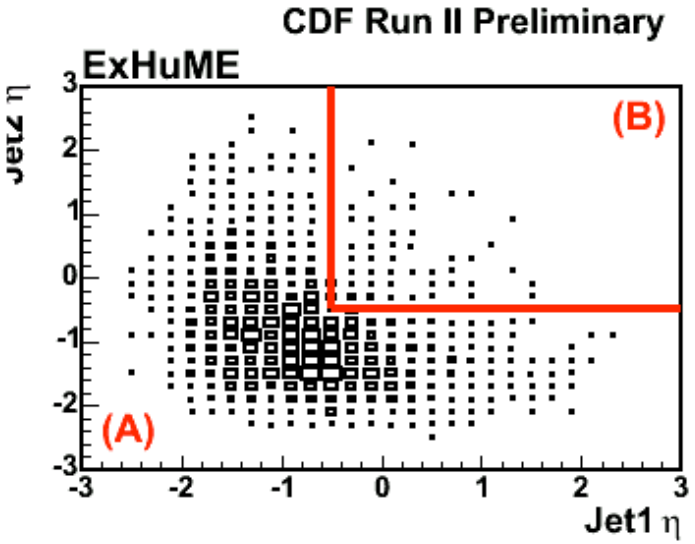


Dijet Plots

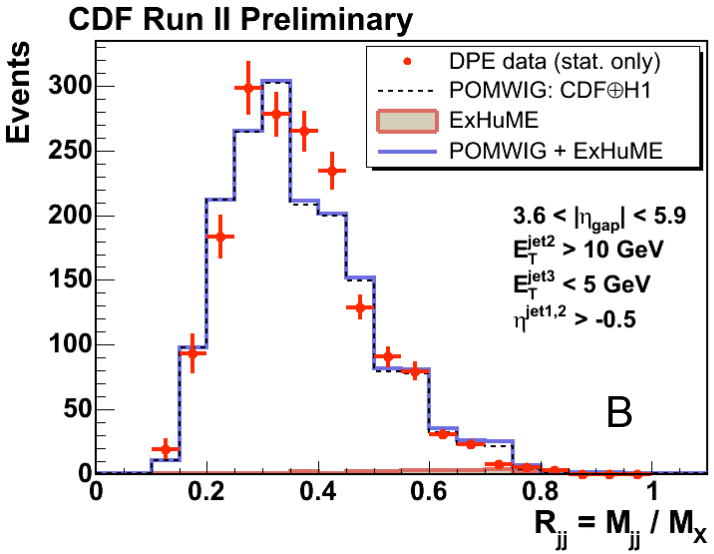


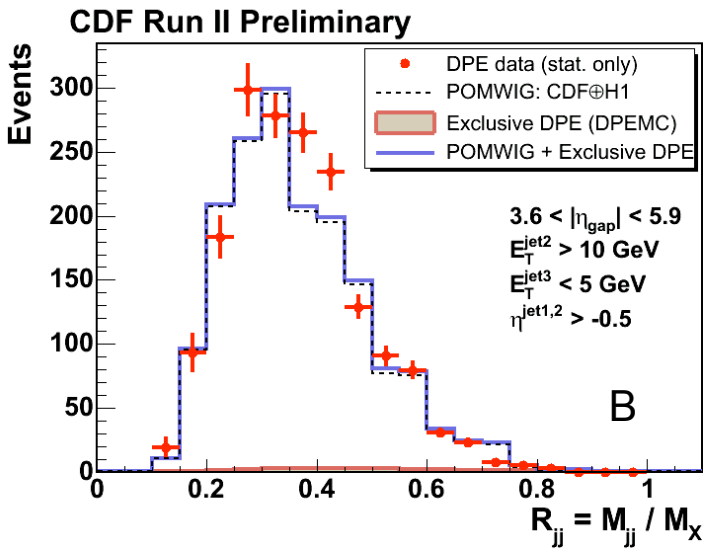


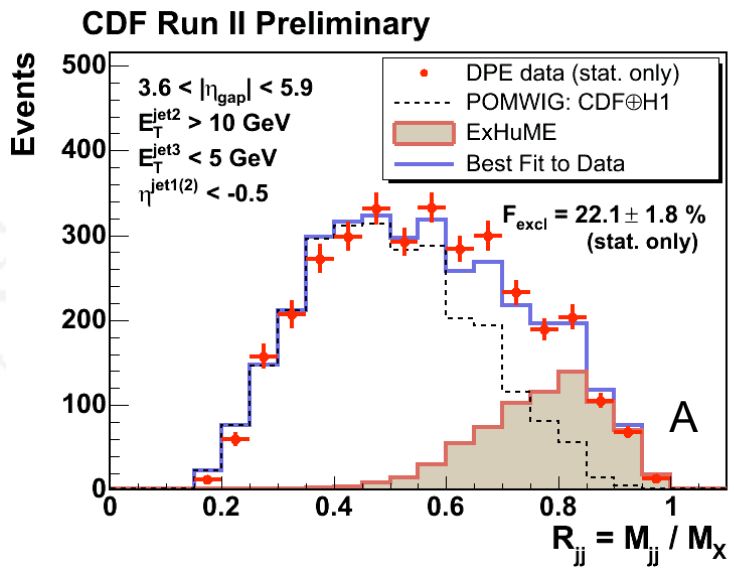


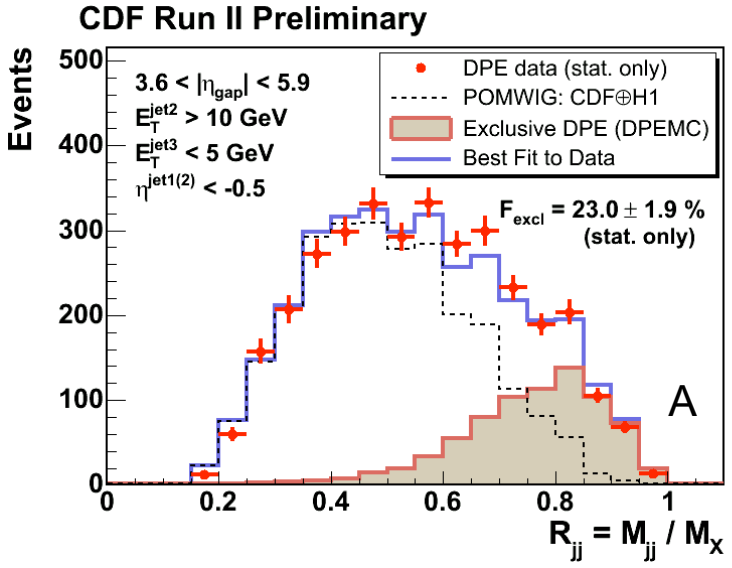


Dijet Plots









Dijet Cross Section

CDF Run II Preliminary

$E_T^{jet1,2} > E_T^{min}$ GeV, $|\eta^{jet1,2}| < 2.5$, $3.6 < \eta_{gap} < 5.9$, $0.03 < \xi_{\bar{p}} < 0.08$, all $t_{\bar{p}}$

E_T^{min}	σincl	σexcl	σexcl/σincl
10	$14.5 \pm 0.1^{+9.8}_{-6.9}$ nb	$1.10 \pm 0.04^{+1.29}_{-0.54}$ nb	$7.6 \pm 0.3^{+2.9}_{-1.2}$ %
15	$1.43 \pm 0.02^{+0.89}_{-0.62}$ nb	$112 \pm 7^{+84}_{-49}$ pb	$7.8 \pm 0.5^{+3.2}_{-1.2}$ %
20	$267 \pm 6^{+166}_{-110}$ pb	$15.7 \pm 2.0^{+15.5}_{-9.6}$ pb	$5.9 \pm 0.8^{+3.0}_{-2.1}$ %
25	$76.0 \pm 2.7^{+37.0}_{-28.6}$ pb	$4.84 \pm 0.96^{+4.11}_{-3.28}$ pb	$6.4 \pm 1.3^{+4.6}_{-3.9}$ %
35	$14.6 \pm 1.2^{+5.3}_{-5.2}$ pb	$1.37 \pm 0.49^{+1.08}_{-1.01}$ pb	$9.3 \pm 3.4^{+6.9}_{-6.6}$ %

(stat. + syst. errors)